Section II:
Marine and Coastal Climatic Atlas

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The marine observations used in computing the statistics for the maps, graphs, and tables in this section of the three-volume atlas were taken from the National Climatic Data Center's (NCDC) marine surface data files which include the Comprehensive Ocean Atmosphere Data Set (COADS). COADS is the result of a multiyear effort by NOAA and the National Center for Atmospheric Research (NCAR) to provide a quality-controlled marine data set which incorporates data from a variety of global sources for 1854-1979. Those files are: TD-1170 for COADS and TD-1129 for 1980-1985. Because relatively little data exist for near-coastal zones, observations from 66 U.S., Canadian, and Russian coastal stations were combined with the marine data in order to present the best possible climatological picture of the outer continental shelf waters and coastal regions of Alaska, and adjacent Canadian and Russian regions.

Data for the U.S. and Russian stations were taken from the edited digital files of NCDC and the U.S. Air Force's Environmental Technical Applications Center (ETAC) in Asheville, North Carolina. Digital data from the Canadian stations were purchased from the Canadian Climate Centre in Downsview, Ontario. All data were subjected to thorough computer and visual quality control in order to eliminate duplicate observations and exclude questionable elements detected during internal consistency and extreme value checks.

The percentages of the summarized 4.5 million marine and 8.5 million coastal station land observations that contain basic weather elements are:

	Marine	Coastal Stations
Wind	93.8	99.1
Visibility	79.5	97.5
Present weather	82.8	95.7
Total cloud amount	79.6	97.3
Low cloud amount	67.4	57.4
Sea level pressure	93.5	89.7
Air temperature	94.4	98.6
Wet bulb temperature	59.4	97.7
Sea surface temperature	85.6	—
Waves	65.4	—

The marine and coastal study area for which data were compiled and analyzed was expanded from 50°—80°N and 130°—180°W (in the 1977 atlas) to 40°—84°N and 110°W—160°E in order to afford greater coverage for each of the three atlas areas, with a minimum of overlap between areas. Element statistics (with observation counts) were generated for each of over 2,550 marine squares and 66 coastal stations within the study area, and then plotted by computer on monthly charts which have an albers equal-area conic projection. The marine plots were 1° latitude by 1° longitude squares for the latitude belt 40°—75°N and 1° by 2" areas for 75°—84°N. An analysis was performed on the entire marine and coastal study area in order to permit continuity between the three atlas areas. Meteorologists, aided by computer-drawn isopleth contours south of 65°N, drew isopleths (lines connecting points of equal magnitude) on 420 monthly element maps, and made subjective adjustments to the analyses when data biases or insufficient observations were evident. They also performed consistency checks in the sets of monthly patterns for each element and among elements, as well as comparative checks with other marine atlases and publications (see Reference).

Although more than a four-fold number of marine data above 65°N was available for this presentation than for the same area in the 1977 atlas, the amount remained inadequate to permit a detailed isopleth analysis by meteorologists or by computer-contouring routines. This was especially true for the cooler months when seasonal sea ice prevented ships of opportunity from frequenting the area. Isopleth analyses for the Chukchi-Beaufort Sea area, by necessity, were based principally on the plotted coastal stations' statistics, extrapolations of weather patterns identified in isopleth analyses for the warmer months, the period of greater data availability, and other marine and continental atlases and publications.

To supplement the isopleth analyses, nearly 16,750 monthly statistical graphs, tables, and roses were produced for 50 of the 66 land stations, 16 representative marine areas, and 43 5" by 5" marine areas. The graphics represent the objective compilation of all available data; they were not adjusted for suspected biases, and differences may be found when comparing the graphics data with the isopleth analyses.

For each topic set, all months are grouped in calendar order with one or two pages preceding each set containing the legend and narrative for that set. The legends contain detailed instructions on how to read the graphics and provide remarks which aid in interpreting the data. The following paragraphs contain additional remarks which are likely to be of interest to those called upon to interpret the data and provide answers to specific operational questions. The table on page II-4 describes the data and marine areas for this volume.

A word of caution. The intent of this atlas presentation was to gather and present existing data on climatological conditions within the marine and near coastal areas of Alaska and adjacent Canada and Russia. The data are presented without discussion and interpretations. Given the information presented in the introductory text, legend descriptions with related text, and number of observations (with measures of variability for some) displayed with the graphics presentations, the user should be able to assess the degree of statistical confidence in the presented climatology for a given month and location.

Standard Deviation

Some of the graphs display approximation of the empirical probability of occurrence of selected criteria. This is a major factor in assessing the risk involved in operational planning. For certain elements, unbiased estimates of population standard deviations are given on the graphs to provide a measure of variability. The standard deviation was computed using the expression:

$$s = \left[\frac{N\Sigma x_i^2 - [\Sigma x_i]^2}{N(N-1)} \right]^{1/2}$$

where N is the number of observations in the sample and x_i is the ith realization of the random variable x.

Sea Ice

The ice isopleths presented in Sets 17-19 give the percent probability of finding ice of any kind, ice concentration of one-half coverage or more, and ice thickness of eight feet or more, within the Alaska study area. Actual concentration boundaries, under the influence of changing synoptic meteorological and oceanographic

situations, may vary widely from the averages. An isopleth label, therefore, does not explicitly define the conditions on either side of the line since presence of sea ice is discontinuous in nature and regions of 80% mean ice concentration may be bordering regions of 20% ice concentrations with no intermediate region of 50% ice concentration. However, the inherent continuity of persistence of sea ice features permit an isopleth presentation to provide meaningful information.

The sea ice data were derived from digitized weekly analyses of sea ice conditions based primarily on satellite imagery (90%) supplemented by ship and shore reports, and aerial reconnaissance. These weekly polar sea ice analyses have been operationally produced by the U.S. Navy/NOAA Joint Ice Center (JIC) since 1972. In 1981, JIC initiated a Sea Ice Digitization Program to digitize the weekly polar ice maps as they become available. NCDC was funded by the U.S. Navy to design software and digitize all weekly ice concentration charts available since 1972 and ice thickness charts available since 1980, and produce polar ice atlases based on data through 1982. The Antarctic Ice Atlas was published in 1985, and the Arctic West and the Arctic East Atlases in 1986 (U.S. Navy 1986). The U.S. Navy also funded NCDC to accelerate the digitization of the West Arctic weekly charts through 1985 and produce the ice statistics presented in this atlas.

Low Pressure Center Mowement

The roses and tracks of the low pressure center movement maps presented in Set 22 are based on 20 years of Northern Hemisphere track charts (January 1966 · December 1985) prepared by the National Weather Service's National Meteorological Center. These charts show cyclone tracks based on 6-hourly positions of closed centers. The NCDC was funded by the U.S. Navy to develop the software and digitize some 240 monthly cyclone track charts to permit inclusion of the statistics in this atlas. Frequencies of cyclone centers passing through $5°$ squares were analyzed by meteorologists within the $35°—80°N$, $115°W—160°E$ area of the North Pacific Ocean to obtain the mean tracks. Primary tracks were selected along axes of maximum cyclone center frequency and secondary tracks along axes of moderate frequency.

Persistence of Wind and Waves

Duration and interval tables are presented in Set 23 for wind speed and wave height. Seasonal and annual tables contain objective compilations for 23 grid points in the Gulf of Alaska and Bering Sea. The statistics are based on numerically-derived wind and wave data generated by NCDC using the Hindcast Spectral Ocean Wave Model (SOWM), developed by Dr. Willard J. Pierson and others, in producing U.S. Navy's SOWM Climatic Atlases for the North Pacific and North Atlantic Oceans (U.S. Navy 1985). No SOWM data were available to produce persistence statistics for grid points within the Beaufort Sea (Vol. III) area.

Episodes of durations (continuous hours or days) of events and episodes of intervals (continuous hours or days) between events were tallied for various thresholds. These tables give an indication of how long an episode is likely to last once it has begun. For convenience, the time an episode persisted above a given threshold is arbitrarily referred to as a "duration" of the event. The times between episodes have been termed "intervals." Data were summarized on a seasonal and annual basis because 12.5 years of hindcast data were considered too small a sample to provide representative durations and intervals for long episodes of wind and wave conditions on a monthly basis. The winter season is January-March; spring, April-June; summer, July-September; and autumn, October-December (World Meteorological Organization, 1981).

Return Periods for Maximum Winds and Waves

Tables of estimated maximum sustained wind speeds and wave heights for selected return periods are presented in Set 24 (Set 23 for Volume III).Estimates for winds are presented for 50 coastal stations within the 3-volume area and for 23 marine grid points within the Gulf of Alaska and Bering Sea areas (Vols. I and II). Hourly wind observations for the stations and numerically-derived wind and wave data generated by Pierson's Spectral Ocean Wave Model (SOWM) for the marine grid points were used in determining the wind and wave extreme estimates. No SOWM data were available for the Beaufort Sea (Vol. III) area. Following the method outlined by Lieblein (1954, 1974a, 1974b), these estimates were obtained by initially fitting an extreme value distribution to each station and marine grid point sample containing N maximum monthly or annual wind speed or wave height values, then inverting the distribution and computing extreme values for selected probabilities. Confidence bands were then computed following the techniques of Gumbel (1958), and Gumbel and Lieblein (1954).

The extreme value distribution has the form:

$$F(x) = F(x:\mu,\beta) = \exp\left[-\exp\left(-\frac{x-\mu}{\beta}\right)\right]$$

where $F(x)$ is the probability that our observations are equal to or less than the specified value x, μ is the mode, and β is the scale parameter. Since the wind data were transformed logarithmically, μ and β refer to the transformed data, not the wind maxima. The values given in the tables of Set 24 are the result of applying the natural logarithms of the N annual extreme wind to the extreme value model, determining the μ and β for each data set, and them exponentiating the logarithms of the estimates to give the probability estimates in knots. The wave data were not transformed logarithmically and, therefore, μ and β are in feet.

Graphic presentations similar to Figure 1 of Set 24 were drawn for each month and for the annual values, and are available on microfiche at the NCDC. The year/month extreme data for each station and marine grid point are also available on magnetic tape. These presentations provide a visual indication of the "goodness of fit" of the model to the data. The confidence limits shown by the envelope of lines about the line of "best fit" represent the level of uncertainty in the extreme value estimate corresponding to a given probability. For this study, 68% confidence limits were computed. This means that in 68% of repeated samples, the true extreme value will be contained within these limits.

Duration of Daylight

The duration-of-daylight chart for the Northern Hemisphere defines daylight as the period from sunrise to sunset. The upper scale at the bottom of the chart is for the Northern Hemisphere; the lower scale is for the Southern Hemisphere. For example, daylight on July 20 of any year at 48°N is about 15 hours and 30 minutes for any longitude. The data source was the U.S. Naval Observatory (1945) and is accurate for the entire twentieth century. Further details may be obtained from The *Daylighter* of the Navy Weather Research Facility (1960). Additional light (during twilight) may be usable for many purposes. Duration of daylight in high latitudes (poleward of about 60") becomes increasingly dependent upon atmospheric conditions and refraction, and there may be some departure from the values depicted on the charts.

Figure 23. Duration of Daylight